sources are insufficient suggests that possibly the changing pressures to which the earth's crust is subjected by tidal strains may give rise to piezo-electricity sufficient to explain the negative charge of the earth; the Editor quite independently of Maxwell has elaborated this hypothesis in his Preliminary Studies. The laws of these tidal strains have been studied by Chree, Davison, Darwin, and others.

The thermo-electric currents of Peltier and the piezo-electricity so fully investigated by Gaugain are not sufficient to explain the amount of electricity represented by the currents flowing through the earth's surface, but the piezo-electric currents due to tidal strain may be quite sufficient. The latter represent the conversion of gravity into electricity.

Lord Kelvin, without touching the question as to the ultimate origin of the electrified state, shows that observed phenomena are sufficiently explained by simply recognizing the fact that the atmosphere can be treated as the dielectric of a condenser (like the glass between the two sheets of tin foil in a Leyden jar); the lower or earth's surface is negative and the upper layer of the atmosphere is positively electrified.

But without pursuing further the maze of hypotheses as to the ultimate origin of the electrified state of the atmosphere, we must conclude that this problem is too difficult for immediate solution; it is one of many that a following generation of physicists will undoubtedly cope with successfully.

If we turn to the simpler question of the meteorological phenomena that are evidently associated with atmospheric electricity, we shall find that the best physicists are not yet wholly clear as to the method of formation of lightning and auroral discharges, the phosphorescent glow of the clouds, ball lightning, and other every day phenomena. Is a cloud to be considered as one big conductor or does it insulate and separate the electrified masses on either side of it? Are the great displays to be seen on the summits of the Rocky Mountains due to the influence of the atmosphere or to something going on in the earth beneath? Are large drops really made up by the agglomeration of small cloud particles, or are both the drops and electricity formed simultaneously by the sudden dissipation of unstable molecular equilibrium that exists in supersaturated cloudy air (as suggested by the Editor in his article of 1891 in "Agricultural Science" on the "Artificial Production of Rain")? Do the larger drops of rain really possess a greater electrical density on their surfaces than the small drops and particles, or do they not rather lose their charges immediately either by evaporation or by gentle discharge to the neighboring drops? These and other questions crowd upon our thoughts; but satisfactory replies can only be given after physicists have invented appropriate methods of investigation. Meteorological observers may contribute to the solution of the problems by collecting both general data and special observations of exceptional phenomena, but the discussion of the data and the definitive decision by means of experimentation as to the merits of conflicting hypothetical explanations must be left to the leading physicists of the world.

ANOMALOUS AND SPORADIC AURORAS.

The Editor regrets that the publication of the following interesting communication has been delayed somewhat by the accumulation of material for the MONTHLY WEATHER REVIEW.

In a letter, dated Key West, November 10, 1897, Mr. H. B. Boyer, observer, Weather Bureau, said:

I have the honor to report that the following described phenomenon was observed on the 8th instant, and it is requested that its character be determined, if possible. The description is taken from the daily journal:

A singular phenomenon was observed between 9 and 10 p. m. This consisted of a beam of well-defined light stretching across the sky, similar to the rays projected by an electric search light. At first it was thought that such it was, as there are two men-of-war in the harbor; but the position and permanency of the beam precluded this idea, and it was afterwards found that the phenomenon had been noted on the war vessels. * * *

The luminous beam began at a point in azimuth 230° (counting from south to west) and stretched southward across the heavens to a point in azimuth 330°, with a slight upward tendency and a slight widening. At its northern extremity its width was about ½°, broadening to about 1° at its southern extremity. It remained fixed as regards its position relative to terrestrial objects, and it was noted that stars, in their upward course, were plainly visible through it. The inclination and altitude may be determined from the following: As the constellation of Orion passed the beam it was observed that at 9:50 p. m. the uppermost star in the "belt" and "Rigel" passed through simultaneously; in other words, a line drawn from "Rigel" to the uppermost star in the "belt" of Orion coincided with the axis of the luminous beam. The phenomenon began to fade about 9:45 p. m., and by 10:10 p. m. had disappeared, the fading process beginning at the northern end. By some the beam was seen to vibrate.

The above phenomenon of November 8, 1897, at Key West, occurred at a time when auroras were rarely observed (see the MONTHLY WEATHER REVIEW for November, 1897, Table IX, p. 513), but at the same time, according to that table, thunderstorms were unusually frequent, and the total number of reports for the whole United States was 64 on that day, being the largest number that occurred during the month; 38 thunderstorms were reported on the 7th and 59 on the 9th, so that these three days present us with one-third of all the storms that occurred during the month.

The general distribution of the reported thunderstorms on the 7th, 8th, and 9th was as follows: Illinois, 6, 15, 1, respectively; Indiana, 0, 9, 8; Missouri, 12, 8, 0; Ohio, 2, 13, 13; New York, 0, 2, 11; New Jersey, 0, 0, 8; Pennsylvania, 0, 3, 9; Tennessee, 0, 5, 1; Connecticut, 0, 0, 4; Massachusetts, 0, 0, 4. Other States report one or two only and Florida reported none. Even in Canada thunderstorms were reported at Grand Manan on the 6th and 9th.

General notes relative to the relation between lightning and auroras and anomalous phenomena relating to atmospheric electricity will be found in different numbers of the MONTHLY WEATHER REVIEW, the principal references to which are as follows: 1893, XXI, pp. 291, 292; 1894, XXII, pp. 78, 328, 509; 1895, XXIII, pp. 13, 297, 464; 1896, XXIV, p. 333.

The item on page 297 of the MONTHLY WEATHER REVIEW for August, 1895, is almost a parallel to the case reported by Mr. Boyer at Key West. It describes an auroral arch and streamer, as seen at Charleston, S. C., on August 26. The phenomenon was so unusual as to have given rise to many suspicions, but eventually it was seen there could be no doubt that this was a case of a very local aurora, such as the Editor calls "sporadic auroras," occurring beyond the confines of a region in which thunderstorms were prevailing at the time. These sporadic and local auroras must be considered as one of the mildest forms of electrical discharge in the atmosphere. It may be that the electricity distributed all over the surface of a globule of water in a cloudy mass or in a hazy sky is collected at the extremities of the spicule of ice when that globule is frozen. The auroral light therefore emanates from definite points and lines located near or above that layer in the atmosphere at which freezing temperature has just occurred. (Small globules may cool far below 32° F. before they freeze to ice needles.) This may be, and undoubtedly is a very irregular surface, but must have a close analogy to the shapes that we see depicted in the clouds and auroras themselves. The beautiful streamers of cirrus haze, as observed in the daytime, have often been compared with the beams, arches, and folds of auroral light, as seen at nighttime. It is quite plausible that both at Charleston, August 26, 1895, and at Key West, November 8, 1897, a discharge of electricity was taking place horizontally outward in all directions from an area of low pressure or

cyclonic disturbance central in the Ohio and Mississippi watersheds. The storm area was particularly well marked on November 8, 1897, as it moved from Illinois to the St. Lawrence Valley, and the system of south and west winds on its southeastern side extended as far as the southern stations in Florida, excepting only Key West. Above these lower winds were the cold westerly upper currents. The region of numerous thunderstorms attending this area of low pressure extended from Illinois to Massachusetts and southward to Tennessee, as shown by the figures above given. Occasional sporadic thunderstorms were reported on the 7th, 8th, and 9th, as follows: Arkansas, 0, 1, 0; Kansas, 2, 1, 0; Louisiana, 0, 2, 1; Kentucky, 0, 2, 0; Maine, 0, 0, 2; Maryland, 0, 0, 2; Michigan, 0, 2, 0; Mississippi, 0, 1, 0; Nebraska, 2, 0, 0; New Hampshire, 0, 1, 1; Rhode Island, 0, 0, 1; Texas, 0, 1, 0; West Virginia, 0, 0, 1. There is, therefore, no reason to doubt but that the disturbed electrical condition extended southeastward from the storm center into Florida, although of course the intensity of the disturbance in that region may have been exceedingly feeble. The temperature at Key West ranged between 65° and 75°, and one would, therefore probably have to ascend 10,000 feet before coming to a temperature of 32°. Between Key West and the storm center the whole country was covered with warm southerly winds, and the height of the isotherm of 32° may have been even more than 10,000 feet. In this region the disturbed electrical condition was relieved by the lightning flashes of the numerous thunderstorms. The air that was not thus suddenly brought to electric equilibrium could, by retaining some of its electric charge, eventually give rise to an aurora when its free electricity was being silently dissipated in gentle streams from the points of snow crystals and their elementary spiculæ.

MOONSHINE AND FROST.

Referring to an article under the above caption in the MONTHLY WEATHER REVIEW for March, 1898, Dr. J. W. Kales, M. D., Franklinville, N. Y., says:

The idea conveyed in that article is that frosts occurring before full moon are not injurious to vegetation, while frosts occurring after the full moon may be injurious.

During the night of May 12–13, 1895, a frost occurred in this section of New York State. It completely destroyed the grass crop and all growing crops; even killed the leaves on the trees, and in some places killed the trees. The leaves turned as brown as in October, and the meadows were as bare of grass as in September. In a word, it destroyed every kind of vegetation. The effects of this frost are still felt throughout this section. The full moon occurred on the evening of the 18th of May, 1895.

These facts are not in accord with this moon theory. Hence, like the other moon theories, this one is all "moonshine."

WATERSPOUTS.

The following extracts from newspapers refer to some special features of waterspouts which it is desirable to put on record.

From the Daily Globe, of June 21, Pensacola, Fla., we take the following:

On Monday, June 20, in the morning, a spout formed on the west side of Pensacola Bay, near Black Hammock, in the shape of a little whirl, and started across the bay in a straight line, gathering force and volume as it went, until it struck on the east bank, near the mouth of East Bay, where upon a sudden it seemed to make connection with an immense black funnel-shaped cloud, forming a complete tube to the water, which it sucked up in immense quantities. The rotary motion of the cloud or spout twisted off the tops of the pines, and they could be seen going up the spout as through an immense glass tube, the water and tree tops rushing up with fearful velocity, when of a sudden it [the spout] seemed to lift from the water, and, with a swiftly rolling motion, gradually drew up into the cloud, whither it gradually spread and disappeared over the expanse of sky.

Those who witnessed this immense waterspout state that it was the largest and most perfect one ever seen in these waters.

From the Press, July 19, Cleveland, Ohio, we take the following:

A remarkable cloud formation appeared in the northwest sky over the lake late in the afternoon of Monday, July 18. It was large and black and boiled and whirled in an angry manner. The shape was that of a cone lying on its side instead of point down like a tornado cloud. Above and beneath the threatening inky cloud the bright sun shone. Shortly after the cloud's first appearance the sky became fully overcast and a heavy rainfall ensued. The whirling motion possessed by the cloud was almost at right angles to that of a waterspout, since in the latter the point of the cone extends nearly straight downward.

PERIODIC FLUCTUATIONS OF THE GREAT LAKES.

Mr. F. Napier Denison, of the Meteorological Service of Canada, and who has just been assigned to duty in British Columbia in order to build up a forecast system for that region, has lately published in the Canadian Engineer a paper on the "Great Lakes as a Sensitive Barometer." Mr. Denison seems to have begun the detailed study of the subject in 1896, and at once proceeded to construct a self-recording gauge showing the fluctuations of Lake Ontario at the mouth of the Humber River, 3 miles west of Toronto, on quite a large scale as to time and amplitude, viz, 1 inch of paper for an hour of time and a quarter of an inch of paper to an inch of fluctuation of the water level. A second self-recording apparatus was subsequently set up in September, 1896, at the Burlington Canal, at the southwest extremity of Lake Ontario, about 40 miles from Toronto. The records given by Mr. Denison's instrument are on a somewhat larger scale than those of the ordinary tide gauge, and in its latest construction Mr. Denison has added another record equivalent to that of a water barometer. Thus, on the same recording sheet we have the records of atmospheric pressure, and, therefore, the ability to make a minute comparison between this and the lake level.

1. Mr. Denison finds that when the lake record is least disturbed, so also is the barometric trace.

2. When the lake undulations become large and rapid so do the oscillations of the atmospheric pressure.

3. The larger undulations in the lake have a period that averages twenty minutes, and the smaller ones average ten minutes.

4. The lake level is never stationary, but the smallest movement recorded for twelve consecutive hours was from one-half to one inch when the pressure trace was also very quiet.

5. Mr. Denison further concludes that the longitudinal and transverse seiches in Lake Ontario are due to great differences of atmospheric pressure between the extremities of the lake, which differences are doubtless augmented when the gale strikes the surface of the water. The longitudinal seiche has a period of four hours and forty-nine minutes, but the transverse seiches only forty-five minutes. When the isobars, as shown on the daily weather maps, lie parallel with the axis of the lake, the seiche movement becomes almost imperceptible. These seiches appear shortly before the passage of some severe storm and for several days thereafter.

6. The rapid heaping up of the water at the upper end of the lake, which is due to great differences of pressure in conjunction with the action of the wind, sets up powerful currents at the top and bottom of the lake, and after this disturbance of water level is over the seiche or oscillation of the whole lake begins.

7. In connection with Helmholtz's paper on atmospheric billows Mr. Denison suggests that the smaller undulations are due to the direct action of the atmospheric waves or billows as they move over the surface of the lake.

8. That these undulations in the lake level become rapid and of great amplitude during fine weather and rising or